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THE SIGNIFICANCE OF THE DIAMETERS OF THE INCISORS IN RODENTS.

BY JNO. A. RYDER.

Upon making sections of the cutting or incisor teeth of various species of rodents and rodent-like animals, it is observed that a great disparity exists amongst the various forms in respect to the ratio of the antero-posterior to their transverse diameters. This character is sufficiently marked to divide the order into two sharply-defined groups as follows:—

a Incisors wider than thick;[1]
b " thicker than wide.

A number of species falling under the definition of group *a* may be arranged in a series in which the final terms approach group *b*, thus, *Mesotherium*, *Lepus*, *Lagomys*, and *Phascolomys*, the marsupial. In the same way, a series may be arranged which shall represent a gradual intensification of the character as indicated in the definition of group *b*, thus, *Castor*, *Lagostomus*, *Cavia*, *Mus*, *Calamodon*, and *Anchippodus*, amongst Tæniodonts; *Sciurus* and *Cheiromys*, amongst primates. The curvature of the upper incisors in group *a* is greater than in *b*, that is, an arc which will coincide with their curvature is the segment of a smaller circle; in both groups the curvature of the lower incisors is less than that of the upper ones. In the last and extreme type of group *a*, the antero-posterior diameter of the lower inner incisor is to its transverse as 1 is to 3; conversely, in the extreme forms of group *b*, the antero-posterior diameter very greatly exceeds the transverse, the ratios being as 3, or even more, is to 1. These contrasts become visually apparent in the cut, where the diagrams of cross-sections of incisors of rodents and rodent-like animals all stand in the same position with reference to fore and aft and lateral directions.

The two groups may be further distinguished as follows:—

a Gnawing apparatus not so powerfully developed or specialized;
Temporal muscles feeble, or inserted very close to condyles;
Crowns of incisors widely separated from pterygoid processes;
Incisive alveoli extending as far as, or a little further back than, the symphysis mandibuli.

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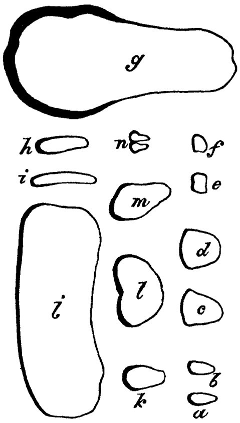
[1] This grouping, it should be remembered, is entirely morphological.

b Gnawers of hard substances; incisors greatly developed;
Temporal muscles and pterygoid processes strongly developed;
Crowns of incisors relatively near pterygoid processes;
(Masseters greatly developed, *Castor*);
Incisive alveoli extending beyond symphysis mandibuli, and often reaching to the base of the pterygoid processes.

The diametrically opposite structural characters pointed out signify more or less diametrically opposite habits. The genera of group *a* have relatively weak incisors as compared with those of *b*, which is in obvious correlation with the feebleness with which they manifest the gnawing habit. Whatever may have been the ways in which the incisors of *Mesotherium* were used, it is very evident that they could never have been used in the same way as those of the squirrel and beaver. They appear to have been wholly adapted for cropping herbage, and not in the slightest degree for gnawing. The *Leporidæ* and *Lagomyidæ* with their feeble incisors have also a very moderately developed gnawing habit, which is in accordance with the weakness of their incisive mechanism. The presence of an accessory pair of incisors of weaker development in the lower jaw of *Mesotherium* and in the upper jaw of the *Leporidæ* and *Lagomyidæ*, the deciduous outer, upper, and lower pairs in *Cheiromys*, the apparent continuity of the incisive with the molar series in the *Tæniodonta*, give us a hint as to the probable manner in which the evolution and functionalization of the median anterior pair of teeth (incisors) came about in the gnawers and aberrant gnawing forms of other orders.



a, cross-section of a lower, *b*, of an upper, incisor of the squirrel; *c*, do. of a lower, and *d*, of an upper, incisor of the beaver; *e*, do. of an upper, and *f*, of a lower, incisor of the hare; *g*, cross-section of a lower incisor of *Calamodon simplex* (after Cope); *h*, do. of an upper, and *i*, of a lower, incisor of *Cheiromys*; *j*, do. of an upper incisor of *Mesotherium cristatum*; *k*, do. of an upper incisor of *Cœlogenys*; *l*, do. of an upper incisor of *Hydrochœrus*; *m*, the form of the obliquely worn face of an upper incisor of *Phascolomys*; *n*, cross-section of both upper incisors of *Cavia aperea*. The anterior portions of the sections look towards the left hand.

It may be said, in a general way, that the excess of the antero-posterior diameter of the chisel-like incisors of group *b* over their transverse one is in obvious correlation with the hardness of the substances which they are designed to cut. The illustrations which verify this assumption are sufficiently striking to make the principle clear. I will cite but four. The beaver is notorious for the magnitude of the work he will accomplish with his busy jaws and incisor teeth, which are in the form of curved, subtriangular prisms: a form well adapted to secure strength, and frequently met with amongst the cavies, porcupines, and chinchillas, though, in the latter, a cross-section often approaches more the form of an isosceles triangle with its most acute angle pointing in a backward direction. This form of tooth, of course, has the same mechanical advantages to resist breaking strains as that with the sides nearly parallel, as in the squirrel. Incisor teeth, pyriform in section, are found in the guinea-pig and the fossil Tæniodont *Calamodon;* this, like the last, has similar mechanical advantages. The squirrel,[1] with its power of gnawing the exceedingly hard covering of nuts to obtain their nutritious contents, is a second familiar example. The destructive abilities of mice and rats are due to the form of their incisors and powerful masseter muscles. Lastly, *Cheiromys*, the insectivorous lemurine primate, beaver-like, gnaws open the burrow of its prey, the larvæ of wood-boring insects. The incisors of this group, constructed, as they are, with reference to the use of the least amount of material, are still further strengthened by their form; that is, they are curved in such a way as to cause the lines of greatest strain to pass longitudinally through a great part of the mass of the tooth. This end is attained in the beaver and squirrel by an admirable arrangement of the masseter muscles, the fibres of which are disposed in lines parallel to that of the greatest strain exerted upon the lower incisors. This arrangement of muscular fibres also admits of the application of the whole of their power without mechanical loss, which would not be the case did not such parallelism exist. Whatever strain passes transversely through the teeth, and which may more properly be regarded as breaking strain, must pass through their long diameter; in this way the same mechanical advantage is secured as where a builder places a horizontal beam in such a position that the greatest strain shall fall through its greatest diameter.

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[1] One African species is reported as gnawing ivory, by M. Du Chaillu, but only on the authority of the natives. He has named it on this account *Sciurus eborivorus* (see Proc. Boston Soc. Nat. Hist. vol. vii. p. 363). Prof. Cope informs me that, on the plains, the fallen antlers of deer are gnawed by rodents; and some assert that they are entirely eaten up in this way, which is held to account for the infrequency with which they are ound where many thousands are annually shed.

The foregoing facts may then be interpreted thus:—

1. Where the incisors are wider than thick, the gnawing habit is feebly developed.

2. Where the incisors are thicker than wide, the gnawing habit is greatly developed.

That is to say, a certain manner of using the incisor teeth (to gnaw) has been a continuous stimulus to which growth force has been as continuously responsive. The opposite forms of development have thus been the result of stimuli differing in kind and degree. According to this view, plastids are brought in increased numbers wherever an increased amount of work is to be done, while at the same time an increased waste of structure is going on, solely by the operation of the above causes, while those causes are in and of themselves wholly passive. Illustrations immediately occur to us where we have the working of such principles displayed: in muscular work, *massage* and alterations in the form of parts due to the establishment of new and approximately normal relations with the environment, as happens in unreduced dislocations and fractures; the thickening of the epidermis of the knee, as on the sole of the foot, and due, like the last, to frequent and similar contact with the earth as a passive stimulus.

The significance of accessory rudimentary incisors present in some forms of true rodents, as pointing to the manner in which the evolution of the rodent type of dentition took place, may be overrated, yet, when it is borne in mind that in other groups the appearance of diastemata between the different kinds of teeth took place gradually, and in a way which unmistakably shows the gradual steps of the process, we may be excused for thinking the same to have been the case here, although without positive, tangible evidence in the shape of intermediate fossil forms that exhibit such a passage from the ordinary type. We have four instances pointing towards a progressive functionalization of the median pair of incisors as gnawing teeth, and this, taken together with the evidence yielded by their forms in section, induces us to venture the reflection that the more severe strains to which they were subjected by enforced or intelligently assumed changes of habit were the initiatory agents in causing them to assume their present forms—such forms as were best adapted to resist great strain without breaking. I am aware that this relation between function and structure, in the case of the incisors of rodents, has been pointed out long since, but it seems to have been coldly received by most anatomists, perhaps because not in accordance with the theory of special creations. Not wishing to discuss the merits of such an objection, it seems to us far more reasonable to believe that organisms are gradually shaped (modified, transmuted) by forces under the surveillance of an orderly reign of law, *i.e.*, to a series of mechanical causes producing morphological effects, than to resort to an endless chain of special expedients to account for the facts.

In respect to the changes in the mandibular articulation and muscular motor apparatus of the jaws of *Rodentia*, I venture to suggest that these have had an origin similarly due to enforced or intelligently assumed changes in the mode in which their functions were exercised. The molar teeth have also been modified by the same agency, as will be shown elsewhere.